Indian J. Phys. **64A** (4), 281-284 (1990)

Photoelectret characteristics of (ZnSe-PbO) systems

Manoj Kumar Chaturvedi and S G Prakash
Department of Electronics and Communication, University of Allahabad, Allahabad 211 002, India

Received 1 September 1989, accepted 28 March 1990

Abstract : The present paper deals, with photoelectret characteristics of mixed lattice of ZnSe and PbO, PbO, which forms the solid solutions with ZnSe, shows maximum photoelectret effect for 10% PbO. The dependence of photoelectret charge on various parameters such as time of polarization, applied field, and intensity of illumination has been studied to determine the optimum conditions of maximum charge storage. The effect of wavelength has also been studied.

Keywords : Polarization, mixed lattice, electrets, dielectric.

PACS Nos : 77.30.+d, 78.65.-s

1. Introduction

The electret (Gross 1971) is a state of dielectric where it acquires permanent electric polarization which persists long unless disturbed. The spatial group of photo sensitive material with barriers get polarized under joint action of field and radiations and are termed as photoelectrets (Nodzhakov 1938, Pillai and Goel 1971). The photoelectret is formed as a result of spatial distribution of photo-carriers in presence of external field and their localization near the electrodes. The illumination causes transition of electron from valence-band to conduction band where electrons move along the direction of applied field. These electrons then leave the conduction band and are trapped in trapping level below the edge of conduction band in the energy gap region. The amount of charge storage is found to be function of various parameters such as polarizing field, temperature, duration of polarization and dark depolarization, intensity of illumination, excitation wavelength etc. The various cell characteristics like binder material and nature of electrode in contact also have their own effect.

ZnSe (2.6 eV) being photosensitive material when mixed with PbO (2.3 eV) to form a solid solution is (Lehmann 1967) found to exhibit photoelectret characteristics. Thus the composition becomes an effective parameter to control the photoelectret property. The effect of various parameters, viz., firing temperature, intensity, time of photo polarization and dark polarization, field, wavelength of

illumination have been studied in detail to explore the optimum conditions of charge storage.

2. Experimental

The solid solutions of ZnSe and PbO were prepared by taking the high purity base material in different proportions and firing them in furnace (cylindrical) in air atmosphere. The optimum firing time and temperature were found to be 30 min and 700°C.

The product was mixed in molten cerin wax sandwiched between two parallel plates. The lower electrode was a plane polished aluminium plate, while upper one was transparent and conducting glass. The cell was mounted in a dark chamber with a window on top, where from it could be illuminated with the help of a 300W mercury lamp. A highly stabilized dc field of the order of 10 KV/cm was applied across the cell through a DPDT-Switch that short circuits the cell through a graphic recorder. The desired wavelengths of illumination were obtained using Hg-filters.

To measure the electret charge the cell was first illuminated in presence of DC field (upto 10 KV/cm) resulting in photopolarization of the sample. The illumination was now cut off and the electrodes were short circuited. The carriers which were not trapped diffused and recombined giving rise to dark depolarization. After stabilization the cell was reilluminated in absence of field thereby releasing the trapped charges. This gives rise to photo depolarization, which was recorded on a Y-t graphic recorder. The time integral of which gave photoelectret charge (Q_{ph}).

3. Results

Three samples, upto 40% PbO content were prepared by heat treatment technique. The photo electret charge varies with composition of the lattice. The maximum photoelectret charge (Q_{ph}) was found with 90% ZnSe and 10% PbO. So the general measurements were made with 90% ZnSe and 10% PbO. The effect of various parameters on Q_{ph} is discussed as following.

(1) Effect of field :

The free charges generated in photoelectret material drift due to the presence of external electric field and get trapped in trapping levels. Hence polarizing field plays an important role in the formation of photoelectret. It has been observed that increase in polarizing field is followed by increase in total trapped charge. It is because as we increase the polarizing voltage, the spatial shift of charge carriers increases and thus reduces the recombination probability. Kallmann and

Rosenberg (1955) observed that no saturation is observed with field, except in few cases. Any saturation effect is not due to complete filling of traps, but related to the kinetics of electrons.

Figure 1 shows the effect of field on photoelectret charge of (75 ZnSe−25 PbO) sample. In this case dependance of Q_{ph} is almost linear and shows no saturation effect.

(2) Effect of intensity :

As the intensity of illumination is increased, the density of free carriers available for trapping increase. It is seen that at low intensities, the photoelectret charge increases rapidly and then shows a saturation effect at higher intensities (Figure 2).

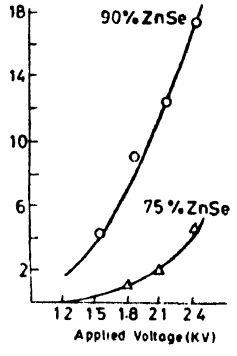

Figure 1. Variation of photoelectret charge with applied field.

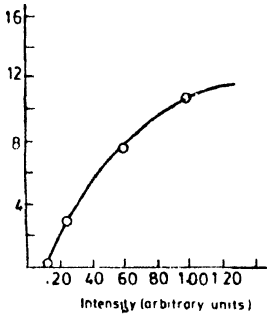

Figure 2. Variation of photoelectret charge with radiation intensity.

The saturation cannot be due to space charge accumulation, it is due to dynamical equilibrium established between the trapping levels and respective bands under the influence of optically modified fermi levels.

(3) Time of photopolarization :

According to Kallmann and Rosenberg (1955) the dependance of polarization (p) of photoelectret on the duration of photo polarization time (t) is given as $P=P_{max}(1-e^{-t/c})$ where c is the response time. This behaviour is shown in Figure 3. The response time is calculated as 55.1 sec.

(4) Effect of dark depolarization :

It is observed that the photoelectret charge decreases as the dark depolarization time is increased. During dark depolarization the charges at shallow trap levels are released thermally at room temperature and recombine reducing the photo electret charge because during this period, charges trapped only in deep traps are remained to be depolarized by illumination, as shown in Figure 4. The reduction is rapid upto 4 minutes and then it slows down.

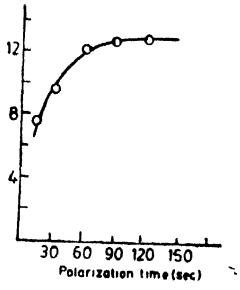

Figure 3. Variation of photoelectret charge with time of polarization.

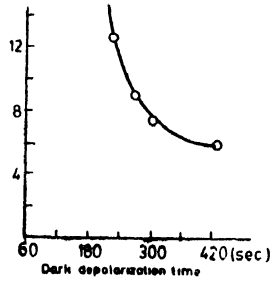

Figure 4. Variation of photoelectret charge with dark depolarization time.

(5) Effect of illumination wavelength :

The Q_{ph} versus λ curve shows a maxima at about 4800 Å (Figure 5). ZnSe has a band gap of 2.6 eV, while PbO has a band gap of 2.3 eV. The band gap of compound lattice (ZnSe-PbO) depends on its composition. The (90 ZnSe – 10 PbO) solid solution is supposed to possess a band gap of the order of 2.5 eV. The light of energy less than the band gap produces less photoelectret charge. According to Kallman and Rosenberg (1955) it is related to absorption of light by impurity

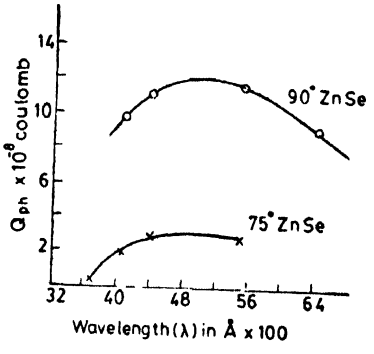

Figure 5. Variation of photoelectret charge with wavelength of radiation

atoms in the dielectric which produces electron transition from activator level to C-band whereas the light of energy more than the band gap is strongly absorbed at the surface only (Bube 1964). It's contribution in bulk excitation is reduced, thereby decreasing the net photoelectret charge.

References

Bube R H 1964 *J. Appl. Phys.* **35** 586
Gross B 1971 *Endeavour* **30** 115
Kallmann H and Rosenberg B 1955 *Phys. Rev.* **97** 1597
Lehmann W J 1967 *Electrochem. Soc. (USA)* **104** 83
Nadzhakov G 1938 Z. *Phys* **39** 226
Pillai P K C and Goel M 1971 *Phys. Stat. Solidi* **6** 9